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Gregory A. Zielinski et P. Thompson Davis

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REPLY TO COMMENTS ON "LATE PLEISTOCENE AGE OF THE TYPE TEMPLE LAKE MORAINE, WIND RIVER RANGE, WYOMING, U.S.A."

Gregory A. ZIELINSKI and P. Thompson DAVIS, Department of Geology, George Mason University, 4400 University Drive, Fairfax, Virginia 22030, and Department of Natural Sciences, Bentley College, Waltham, Massachusetts 02254, U.S.A.

Mahaney's comments on our note are primarily concerned with our failure to cite and discuss his previously published work that he feels is relevant to the age of the type Temple Lake moraine. Mahaney also presents three figures that he claims clarify his comments and his previous work on "the Temple Lake problem". We will reply to Mahaney's comments by reviewing the content of the papers he cites and by discussing the implications of the stratigraphic nomenclature that Mahaney uses in two of his figures.

We read all of the publications that Mahaney cites in his comments before we wrote our note, and we have read them all again before writing this reply. We initially referenced one of Mahaney's publications in our note; however, both reviewers stated that the citation was irrelevant to the main focus of our note, so we omitted the reference in our final draft. The purpose of our note was "to report radiocarbon ages from the basal portions of the sediment cores [that we retrieved from the Temple lake valley] that have a bearing on the age of the type Temple Lake moraine," not to review 15 years of Mahaney's research on soils in Colorado, Wyoming, and East Africa.

Of Mahaney's nine publications that he cites in his comments on our note, one is his unpublished doctoral dissertation on soil genesis in the Colorado Front Range (Mahaney, 1970), one is a short note concerning stratigraphic nomenclature in Colorado (Mahaney, 1972), one presents a tentative lichen growth curve for the northern Wind River Range (Mahaney, 1987b), one proposes a new name for early Neoglacial deposits in Wyoming (Mahaney, 1984), one reinterprets the age of moraines on Mount Kenya in Africa (Mahaney, 1987a), and four are longer papers that describe Quaternary soils, paleoclimate, chronologies, and dating methods (Mahaney, 1978, 1981, Mahaney *et al.*, 1984a, 1984b) published in books he edited himself. Nowhere in these 377 pages of literature does Mahaney provide any numerical ages for the type Temple Lake moraine. Nor could we find in these pages any relative-age data for the type Temple Lake deposits. In contrast, Moss (1951), Richmond (1965), Currey (1974), Miller and Birkeland (1974), and Zielinski and Davis (1987) all provided data bearing on the ages of Temple Lake deposits *at their type locality*.

Mahaney (1978) proposed replacement of the term "Temple Lake" by the term "early". Presumably, Mahaney meant this term to be used for deposits of early Neoglacial age (about 5 to 3 ka), but such an ambiguous term is inappropriate for alpine deposits without a specified type locality (Birkeland *et al.*, 1979; Davis and Zielinski, 1988). Moreover, elimination of the term Temple Lake as proposed by Mahaney (1984) is not a solution to a problem that involves dating the deposits (Miller and Birkeland, 1974). Whether one describes glacial deposits as representing geologic-climatic units (American Commission on Stratigraphic Nomenclature, 1961) or as alloformations (North American Commission on Stratigraphic Nomenclature, 1983), one can not abolish a type locality from the literature, unless the deposits are no longer available for examination. Thus, the name Temple Lake must stand, although we now know that the deposits at the type locality are late Pleistocene rather than early Neoglacial in age. Moreover, glacial deposits elsewhere in the montane western United States that have been correlated to the type Temple Lake moraine by relative-age data now may also be considered late Pleistocene in age.

We reject Mahaney's renaming the type Temple Lake moraine(s) "Late Stade" or "Late Pinedale" (Figs. 2 and 3 in Mahaney's comments), because these terms will only confuse Temple Lake deposits with older moraines that lie well downvalley of cirques throughout the North American Cordillera. For example, Richmond (1986) places the end of Pinedale deposition in the Wind River Range prior to 12 ka. Mahaney's designation "extent of ice unknown" in his Figure 2 is misleading because we now know that the Temple Lake valley glacier was no more than 1.5 km long between about 12 ka and the present (see Zielinski and Davis, 1987, Fig. 1). Based on an abundance of paleoecological data from throughout the North American Cordillera (Davis and Osborn, 1987), the period between 12 and 7.5 ka was probably the warmest time since the Late Wisconsinan, and cirques may have been completely ice-free during this time (Davis, 1988, *in press*). Whether the Temple Lake moraines represent a "recessional stillstand" (Mahaney, 1978) or a minor readvance of glaciers during Late Wisconsinan deglaciation (Davis and Osborn, 1987) is impossible to determine. In either case, the original usage of the term Temple Lake by Moss (1951) for moraines in cirques dating to the late-glacial [late Pleistocene] is perfectly adequate, and should be retained.

Although Currey (1974) and Miller and Birkeland (1974) mapped deposits that they believed to be early Neoglacial in age upvalley from the type Temple Lake moraine, within a kilometer of the contemporary glacier margin, Mahaney (1984)

considered these deposits insignificant. Thus, Mahaney (1984) proposed the term "Indian Basin" for deposits that he believed are early Neoglacial in age in the northern Wind River Range (see Figs. 1, 2, and 3 in Mahaney's comments). Although we believe that a defined type locality is an improvement over the term "early" (Mahaney, 1978), we doubt that the Indian Basin moraines at their type locality date 5 to 3 ka as suggested by Mahaney (1984). As mapped by Mahaney (1984), the Indian Basin moraines lie about 3 to 5 km beyond Little Ice Age moraines fronting Harrower Glacier, and thus appear to represent snow-line depressions correlative with those suggested by other late Pleistocene cirque moraines, such as the type Temple Lake moraine.

In the absence of radiocarbon-datable material in till, one can not expect to obtain the oldest radiocarbon ages for glacial deposits by coring shallow peat bogs with a soil auger; rather, one must recover bottom sediments from deep lakes with the appropriate coring equipment to obtain the oldest minimum-limiting ages for moraines. Mahaney's comment that "there is usually a lower core section that is composed mostly of inorganic sediments and impossible to date by radiocarbon, leaving the investigator to estimate rates of sedimentation and hence [estimate] an extrapolated age for the base of the core" is not "a rather typical problem" from our experience in the Temple Lake valley. To determine basal ages for sediment cores by extrapolating sediment accumulation rates through layers of sand and gravel from radiocarbon ages on overlying lacustrine sediments as Mahaney (1987a) does is scientifically unsound. The coarse clastic sediments that commonly exhibit cross bedding and slump features at the base of sediment cores could conceivably be deposited by a single storm event or by less than a season of fluvial deposition. We considered all of our radiocarbon ages on sediment cores recovered from lakes *upvalley* of the type Temple Lake moraine only minimum-limiting ages for the deposits; we did not use "extrapolated ages for the base of the cores". We also considered a 11.7 ka radiocarbon age on the transition from inorganic to organic sediments in a core from the lake less than a kilometer *downvalley* from the type Temple Lake moraine to mark the time of glacier recession from that moraine. Thus, this radiocarbon age suggests that our oldest radiocarbon age (11.4 ka) upvalley from the type Triple Lakes moraine is closely minimum limiting. In contrast, we are unclear on how a radiocarbon age on an Ab soil horizon buried by purported lacustrine sand is related to moraines some distance away, but Mahaney (1978) considers this age to be a good evidence for the termination of the Indian Basin glacial advance (Mahaney, 1978). The age of the type Indian Basin moraines will only be resolved by better radiocarbon dating control, perhaps obtainable by coring sediments in lakes upvalley of the moraines.

Although not in any sense a focus of our note, Mahaney comments at length about the correlation of *late* Neoglacial deposits in the Wind River Range. He concludes that "the Audubon advance [in Colorado] led to the emplacement of tills with exactly the same degree of post-depositional alteration (our emphasis) as those of the Wind River Range". In reviewing the relative-age data on the Audubon deposits in all of Mahaney's cited papers, we see very little to indicate anything "exact". Mahaney goes on in his comments to complain that we did not reconstruct the Gannett Peak moraines to "reflect the situation [he] observed there". Given that Mahaney never published his map of the Temple Lake valley until now, how could we have possibly shown these deposits on our map the way he envisioned them? Rather, we simply referred to published maps by Currey (1974) and unpublished maps by Miller and Birkeland to guide us. As stated in our note, our purpose was not to re-map the Temple Lake valley, but to provide better ages for the type Temple Lake moraine. Thus, we consider Mahaney's comments on the ages of Audubon and Gannet Peak deposits irrelevant to the focus of our note.

In conclusion, none of Mahaney's publications, including his comments published here, have come to grips with the age and significance of the type Temple Lake moraine. Rather, he has only confused stratigraphic nomenclature by attempting to remove the term Temple Lake from the literature, a perfectly fine name and type locality for latest Pleistocene alpine deposits in Wyoming. Thus, Mahaney's previously unpublished Figures 2 and 3 in his comments do not provide any new information to the literature and would best be ignored until better numerical dating control is available for Holocene deposits in the Wind River Range.

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